4π Deployment Protocol

December 12, 2003

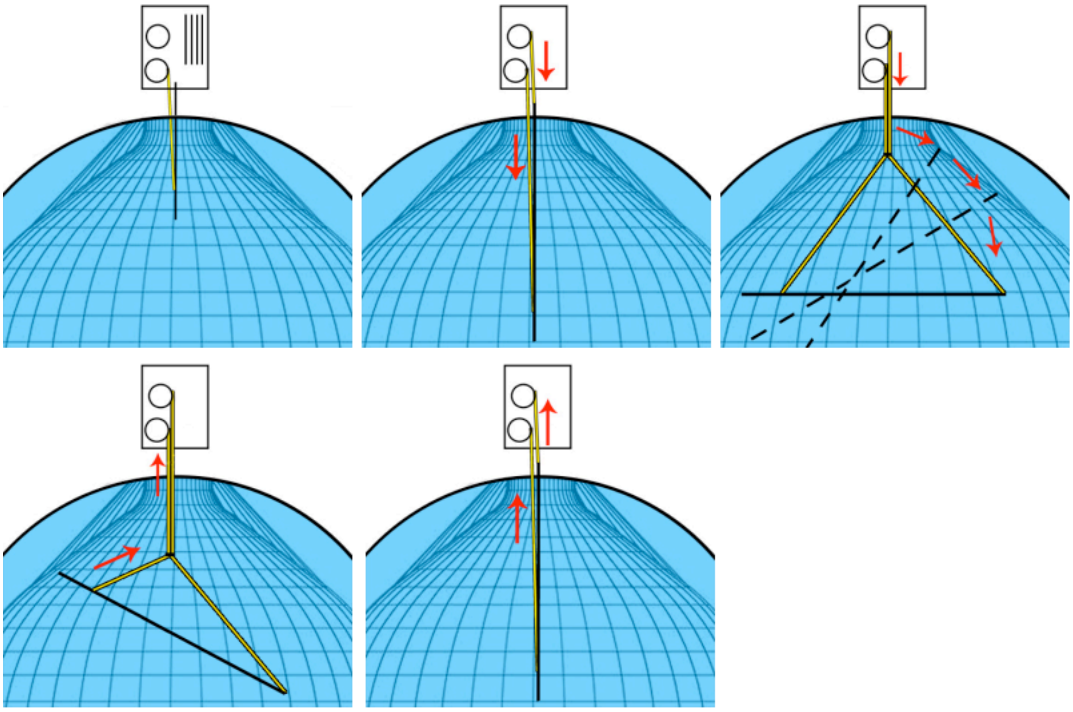

Figure 1: Deployment Sequence

1 Deployment Protocol

1.1 Initial Conditions

1. All tubes are hanging on the storage rack in the glovebox.
2. Both the 6" and the 16" gate valves are closed.
3. The calibration sources (attached to the specialized BTC segments) are in the glovebox, and the glovebox and transfer box have been adequately sealed and purged.
4. Both control cables are fully retracted inside the glovebox, just below their respective guide pulleys.
5. The pin block is firmly attached to the conflat flange on the bottom of the glovebox.
6. The hoist segment and all of the weighted segments are placed in their respective storage racks inside the glovebox.
7. Throughout assembly, one operator will verify and record the following: number of segments used, positions of transducers and cable attachment segments, the masses of the load and the source weight, and the ϕ position (as indicated on rotary stage).

1.2 Preparation for Assembly

1. The hoist segment is placed into the pinblock. (This attachment is a male BTC coupling with a hook welded below it). This segment has two pins. The bottom pin (pin closer to hook) is placed into the pass through slot on the pinblock. It then needs to be rotated 30 degrees CCW to be lowered. This action allows the top pin to rest securely in the torque slot of the pinblock.
2. The top motor driven cable (from now on referred to as the hoist cable for assembly and disassembly operations) is lowered to just above the pinblock. This cable end is permanently attached to a short segment with a female BTC on the other end.
3. The operator then attaches the internal cord. This is done by clasping the snap hook or carabiner hanging from the cable end attachment onto the eye hook inside the hoist attachment segment.
4. The hoist is lowered as the operator aligns the castellations of the two segments. The visual fiducial marks on the two segments are simultaneously aligned.
5. With the castellations aligned and pressed firmly together, the operator engages the threads of the cable segment coupling onto the threads of the hoist segment coupling and hand tightens the coupling.
6. The top cable is then retracted so that the hook end is just below the top pulley in the glovebox. The pole assembly can begin.

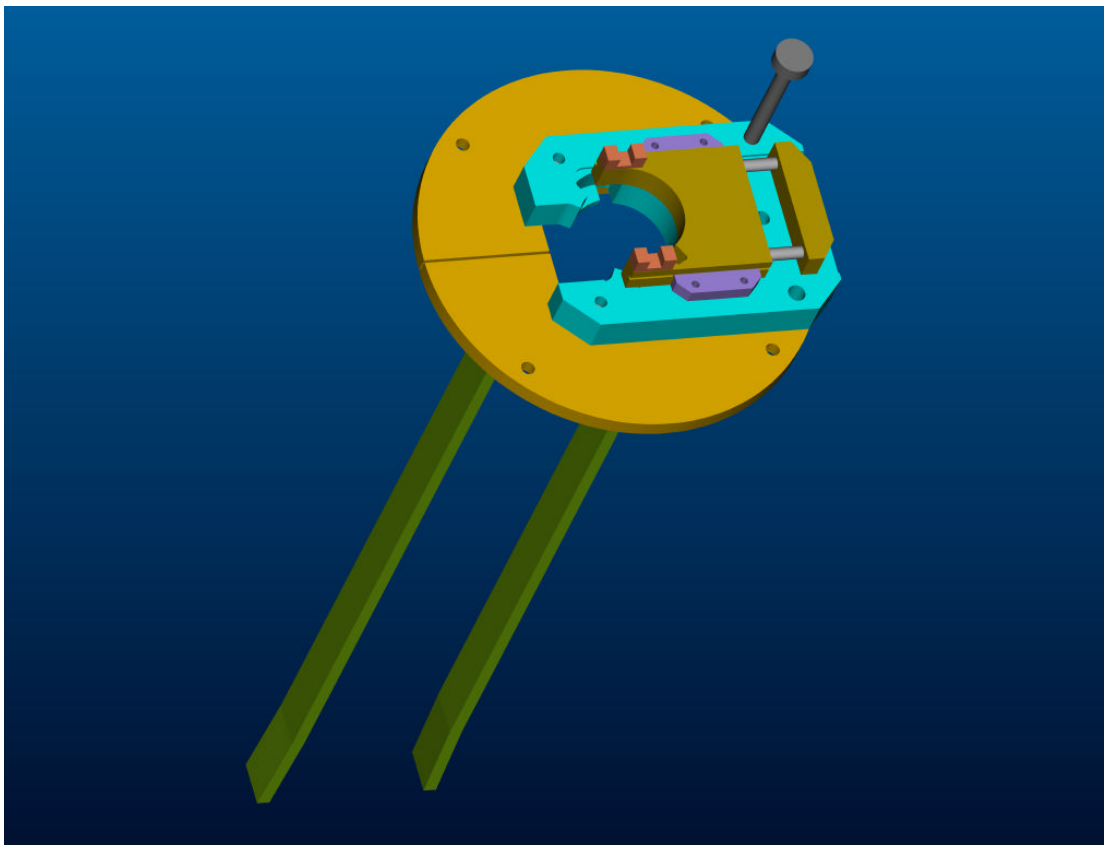

Figure 2: Design of the pinblock

1.3 Assembly of first (source) segment

1. The prepared source segment is accessible inside the glovebox. The source BTC connection is double checked prior to installation.

2. OPENING OF 6 GATE VALVE. This is a manual operation which takes place on the calibration deck. A handle directly attached to the gate valve is turned CCW until fully open.

3. A long internal cord is first attached between the source segment and the next segment in the assembly, which is still hanging in the glovebox rack. The design of this longer cord is to be determined, and is only used for the first few segments as an additional safety until the lower cable segment (third segment) is connected.

4. The first segment with the source is manually placed into the pin block, source end first. Great care is taken to insert the tube vertically, so as to not hit the source against anything in or along the spool. It is placed so that the lower pin is first rotated CW to pass through the pinblock. A step built into the pinblock will prevent further lowering of the segment.

5. Still holding the source segment, the operator rotates the segment 30 degrees CCW. This will naturally lower the upper pin of the segment into the torque slot of the pinblock.

6. Once the segment is secure, the operator can begin to attach the next segment.

1.4 Attachment of second segment

1. The operator manually holds the bottom of the second (or next) segment. This segment may contain a pressure transducer and LEDs. The segment is lifted out of the rack. The operator (with possible manual assist from upper gloveports) places the segment onto the hoist, so that the eye opening of the internal cord inside the tube segment fits onto the hoist hook.

2. The short internal cord is connected between the two segments. At this time internal or possibly (internal or external) electrical connectors on each segment will also be securely attached. The longer cord may be disconnected at this time.

3. The hoist is lowered while aligning the segments until the teeth of the couplings are engaged.

4. The operator first hand tightens the couplings. The operator then uses the supplied, tethered torque wrench to secure the coupling to approximately 25 ft-lbs.

5. Once the coupling is secured, the hoist is raised slightly to lift the lower segment pin out of the torque slot.

6. OPENING OF 16" GATE VALVE. This is done by an operator on the lower deck of the dome area. At this time the detector high voltage needs to be turned off.

7. The operator rotates the assembly to approximately 30 degrees CW to allow the pin to pass through the open slot of the pinblock.

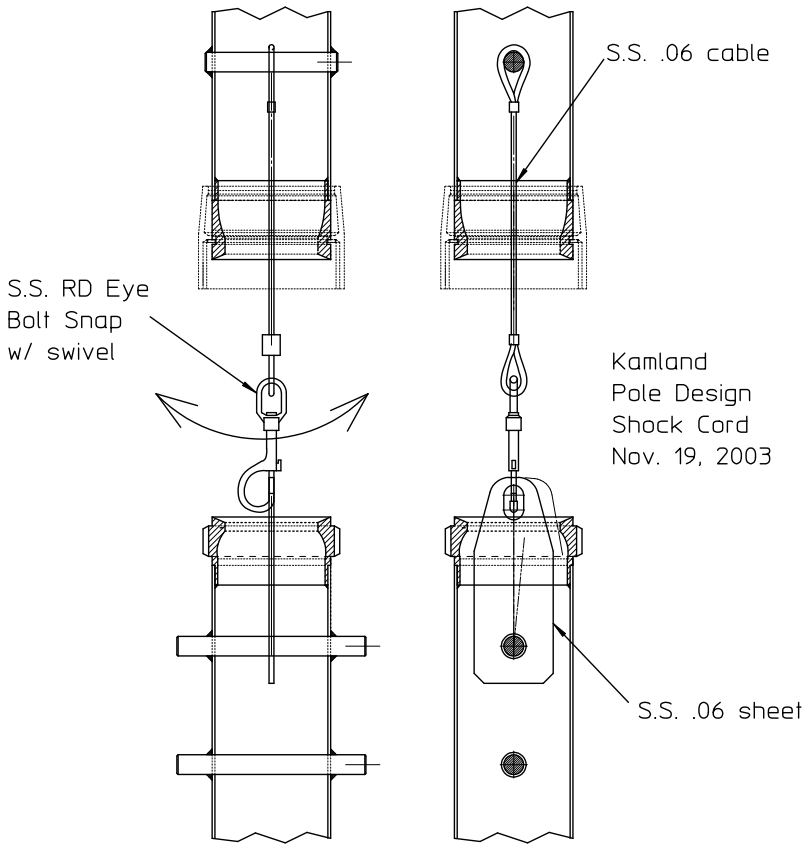

Figure 3: Design of the internal safety cord.

8. The hoist is lowered as the operator guides the top pin of the first segment through the pin block. Once the pin passes through, the operator can manually release the twist on the assembly. The second segment is guided to pass the lower pin through the pinblock (rotation, lowering, and counter rotation) in order to secure the upper pin into the torque slot of the pinblock.

9. At this time a long safety cord between the second and third segments is attached.

10. The operator disengages the hoist from the segment's internal safety cord and raises it to just below the pulley.

1.5 Assembly of third segment (segment with cable attachment):

1. The third segment is lifted from it's designated place in the glovebox and placed onto the hoist hook. This segment is a shorter segment with the lower cable permanently attached.

2. The internal safety cord is connected. Electrical connections are also made between the second and third segments, if necessary. The longer safety cord may be detached at this time.

3. The orientation of the castellations and the visual markings are aligned as the segment is lowered.

4. With the castellations aligned, the operator manually hand tightens the coupling.

5. The final tightening adjustment is made with the torque wrench.

6. Once the coupling between the second and third segments are secure, the operator lowers the second (lower) cable to just above the pinblock.

7. At this time, electrical power to the lower cable can be activated and verified (LEDs work, pressure transducer readout makes sense).

8. The hoist is lifted slightly to release the pin from the torque slot.

9. The pole is rotated 30 degrees clockwise, lowered slightly, released from rotation by the operator, and both cables are lowered until the lower pin of segment 3 reaches the pinblock.

10. The operator rotates the segment, lowers both cables slightly, then releases rotation.

11. Both cables are lowered until the top pin of segment 3 rests securely in the torque slot of the pinblock. It may be necessary to open the sliding pinplate to allow the cable attachment point with the mass to pass through the pinblock. From this point on, the upper and lower cable will be lowered simultaneously when an entire segment length is being deployed. A certain amount of slack (5 inches) needs to maintained on the second cable throughout deployment.

12. Detach the hook and raise the hoist cable.

1.6 Assembly of segments 4...8:

1. Raise the bottom of the next segment out of the rack and place onto the hoist hook.
2. Connect the internal cord between the upper and lower tubes.
3. Lower the hoist cable to align the segments and fit the castellations.
4. Tighten the couplings together and secure with the torque wrench.
5. Lift the hoist cable to release the pin from the torque slot.
6. Rotate the assembly (30 degrees clockwise).
7. Lower both upper and lower cables to allow the pin to pass through the pinblock.
8. Release the rotation of the segmented assembly.
9. Lower both cables simultaneously until the lower pin of the upper segment is just above the pinblock.
10. Rotate the segment 30 degrees CW and lower until the lower pin of the segment passes through the pinblock.
11. Release the rotation and continue to lower both cables until the top pin rests securely in the torque slot of the pinblock.
12. Detach the hook and fully retract the cable to the bottom of the guide pulley.
13. Repeat all of the above steps until the top pin of the final segment is seated in the pinblock. This procedure is the same for all weighted segments, as well. Segments with position determination equipment will also use the above procedure, however electrical attachments will need to be made (details of cable routing and positioning are to be determined).

1.7 Assembly of End Segment

1. The top pin of the last segment is seated securely in the torque slot of the pinblock. The operator detaches the hoist hook attachment from the eye opening of the last segment.
2. The operator disengages the hook attachment from the end of the cable segment by decoupling the BTC and disengaging the internal cord. It is then stored in its appropriate place inside the glovebox.
3. Connect the internal cord between the last segment and the cable end segment. Electrical connectors inside each of the segments will also be connected at this time. An initial check of the electrical connections can be made at this time (example: verifying that the LED functions and the pressure transducer yields a logical output signal).
4. Align the segments while lowering the hoist attachment to fit the castellations together.
5. Secure the coupling and tighten with the torque wrench.
6. Raise the top cable slightly to rotate the assembly.

7. Rotate the assembly to allow the pin to pass through while lowering both cables. A safe amount of slack should always be maintained on the lower cable to prevent pulling and applying torque to the pole from the bottom cable. This slack can be indicated by maintaining a set difference in length between the two cables, as given by a differential reading between the two encoders.

8. Continue to lower both cables until the markings on the cable which indicate the appropriate attachment point for the pivot block are in view. This indication may consist of a mechanical crimp, a colored string wound into the cable, and/or a physical attachment point, such as a tube affixed to the stainless wires. This point can also be honed in on by any of the other three position determination methods.

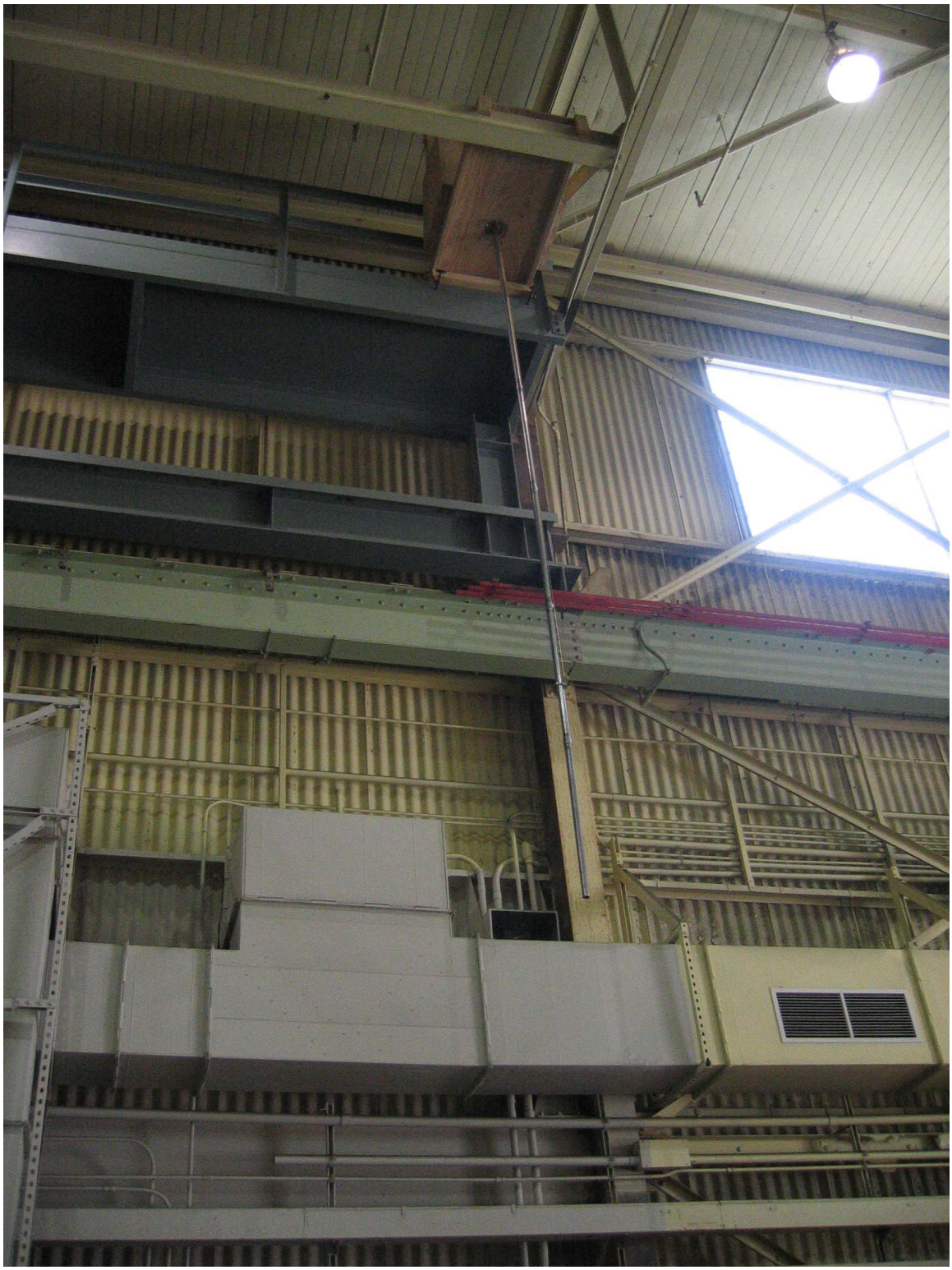

Figure 4: Photograph of the deployment of the prototype calibration pole.

1.8 Attachment of the pivot block:

1. Lower both cables simultaneously until the markings for the pivot block attachment are above the pinblock. This position may vary, based on the length of the assembled pole. Such methods as the number of colored strings wound into the cable at each potential attachment point could indicate to the operators which point to use for a given pole length. Again, this can also be verified by the other position determination equipment.

2. The tethered pivot block is attached at the appropriate place on the cables by sliding the cables into place and securing the side plate of the pivot block. It will be clearly marked which cable becomes the fixed side of the pivot block. The other cable will be routed through the guide pulley side of the block.

3. The cable on the fixed side of the pivot block needs to be securely attached at this time. The operator should check and double check the security of this attachment.

4. If a pressure transducer is being utilized on the pivot block, the two conductive pins should be attached at this time, and the connection activated and verified.

5. Once the pivot is secured, the tether can be removed. The operator slides the spring loaded pin rest on the pinblock and lowers both cables simultaneously. Once the pivot has passed through the pinblock, the slide can be released.

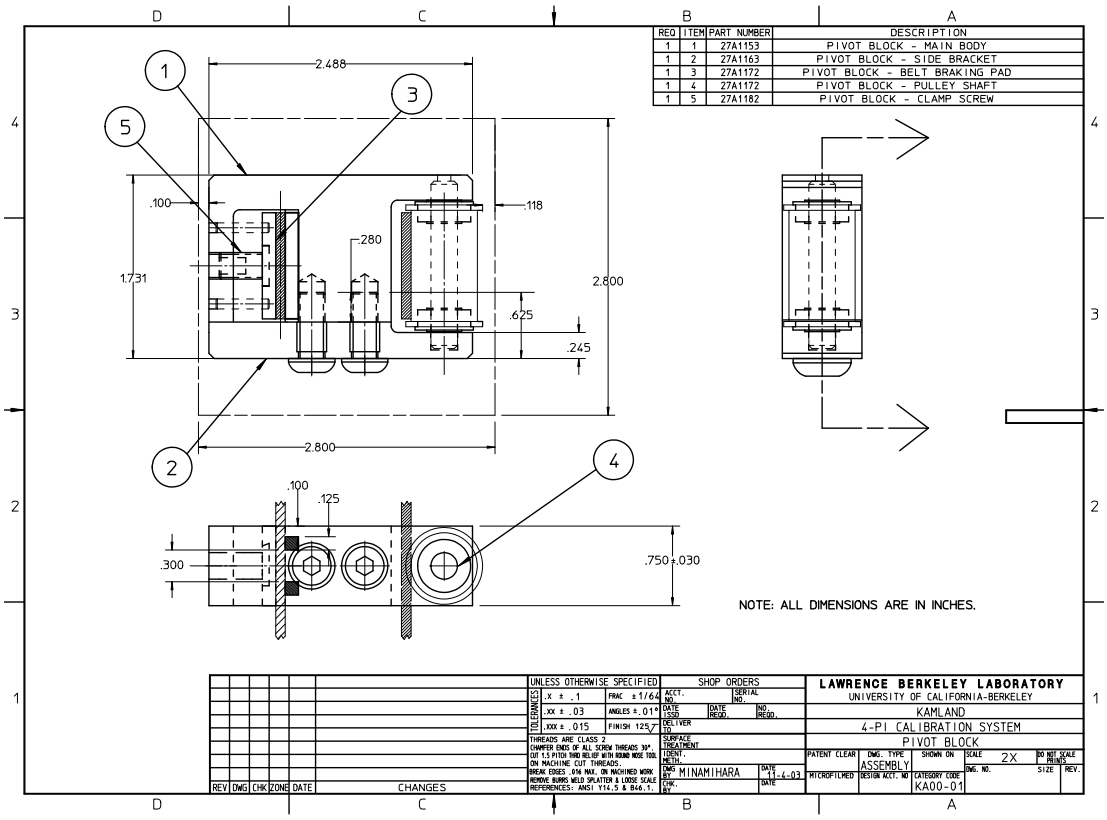

Figure 5: Current Design of the Pivot Block

1.9 Cable Position Calibration

1. During the lowering of the pole, the LEDs mounted on the assembly and the detector CCD cameras can be turned on to allow visual monitoring of the pole during deployment. The functionality of this equipment (i.e., LED wavelength not absorbed by LS) will be verified prior to deployment.

2. The operator tells the controller (through software) the number of segments being deployed, the length from end to end, the length between cables, the position on the pole of the transducers, and the masses of the load and the source. This is verified by the records of the second operator. The controller will then know the center of gravity of the pole based on pre-calculated and pre-programmed information.

3. The pole is now lowered (both cables simultaneously) until the center of gravity of the pole is at the center of the detector. This position will be determined by the (precalibrated) readout of the pressure transducers on each end of the pole. It will be verified by the encoder readouts of the two pulleys. It will also be visually verified by the position of the LEDs on the pole relative to the fixed CCD camera displays.

4. Once the center is in place, the operator will need to slightly raise the lower cable until a visual fiducial on this cable is in alignment with a specified point on the inside of the glovebox (possibly on the guide pulley support bracket), or as indicated by position equipment. This eliminates the slack on the second cable which was needed throughout deployment, and gives a starting position for the second cable encoder readout.

5. The position of the top cable can be adjusted to align a visual mark of the cables to a visual fiducial point inside the glovebox. Once both cables are moved to be in alignment with this point a "start" command can be given to the controller which relates to a prerecorded position for each of the cables. The pulley encoders can now also be set to this "start" position. This can also be verified by pressure transducer and camera information. (Note: this implies a slight angle of the pole, so "start" will be at something like θ= -85 degrees or something similar).

6. The light cover can now be placed over the glovebox. The cameras and LEDs can be turned off (if needed). Initially, a PMT in the neck of the detector can be turned on to verify darkness requirements. The PMT high voltage can be turned on.

1.10 Calibration by Changing θ Position

1. Once the start positions of the pole are verified, the cables can be adjusted in length to place the source at different positions in θ.

2. Once the source is stable (oscillations are sufficiently dampened), the calibration run can begin for the desired length of time.

3. Different θ positions can be preprogrammed into the motor controller, or set increments can be preprogrammed. Incremental motion is the safest method for calibration. The number of positions required within θ need to be determined by the calibration group.

4. The first set of calibration data can be obtained for different θ positions. This set will have the same ϕ position and radial position, and the same calibration source.

1.11 Calibration by Changing ϕ Position

1. Once the first set of data points in θ for an initial position in ϕ is obtained, the glovebox can be rotated to obtain different source positions in ϕ. The safest method for ϕrotation is to retract the pole assembly until the first segment is seated securely in the pinblock. This will avoid unnecessary damping and potential tangling of the cables (especially around the protruding pins).

2. At the end of the θ calibration, the cables will be moved back to the "start" position. This motion will be determined and run by the preset program, to avoid interference in the "excluded" region.

3. PMT high voltage will be turned off, and the cameras and LEDs turned on. The light cover can also be removed.

4. Once at the start position, the weighted end of the pole can be raised slightly until the lower cable is slack. This position will be indicated by the set differential reading between the two encoder pulleys.

5. Both cables can be raised simultaneously until the pivot block is near the top of the spool stack. This may be determined by LED position, encoder readout, and possibly the cable fiducial.

6. The operator pulls back on the sliding plate on the pinblock as both cables are raised. Once the pivot block passes through, the slide plate can be released.

7. The operator detaches the pivot block .

8. Both cables are again raised simultaneously until the top pin of the weighted end segment is near the top of the spool stack.

9. The operator then pulls back on the sliding pin plate and raises both cables until the top pin of the weighted segment is above the pinblock.

10. The sliding pinplate is released and the cable lengths adjusted until the top pin of the weighted segment is securely placed into the torque slot of the pinblock. The assembly is now ready for ϕ rotation.

11. Rotary stage motion is activated through the main motor controller. The change in ϕ position will be given to the controller through the programming software. Care must be taken during rotation to ensure that all of the hardware does not obstruct or is not damaged by the rotating glovebox. This must be done actively by an operator on the calibration deck.

12. Once the glovebox is in the next ϕ position, the pole can be deployed following the above procedure beginning with Section 1.7.6, then continuing through sections 1.8 and 1.9.

13. The next set of θ position data can be acquired, section 1.10.

1.12 Calibration by Changing Radial Position

1. Additional sets of calibration data can be acquired at different radial distances from the center of the detector. This can be done for one source either after one set of θ positions and before rotation, or after all θ and ϕ position data is obtained, then repeated with a different radial distance.

2. At the end of the θ calibration, the cables will be moved back to the "start" position. This motion will be determined and run by the preset program, to avoid interference in the "excluded" region.

3. PMT high voltage will be turned off, and the cameras and LEDs turned on. The light cover can also be removed.

4. Once at the start position, the weighted end of the pole (and/or the top cable side) can be raised slightly until the lower cable is slack.

5. Both cables can be raised simultaneously until the pivot block is near the top of the spool stack. This may be determined by LED position, encoder readout, and possibly the cable fiducial.

6. The operator pulls back on the sliding plate on the pinblock as both cables are raised. Once the pivot block passes through, the slide plate can be released.

7. The operator detaches the pivot block .

8. Both cables are again raised simultaneously until the top pin of the weighted end segment is near the top of the spool stack.

9. The operator then pulls back on the sliding pin plate and raises both cables until the top pin of the weighted segment is above the pinblock.

10. The sliding pinplate is released and the cable lengths adjusted until the top pin of the weighted segment is securely placed into the torque slot of the pinblock.

11. The operator uses the torque wrench to disengage the cable end segment from the end of the weighted segment.

12. The upper cable is lifted slightly to allow the operator to disengage the internal safety cord.

13. At this time the hook attachment piece can be attached to the cable end BTC. This is done by first attaching the internal cords between the two pieces. Then the operator aligns the castellations and firmly hand tightens the coupling.

14. At this time, either an additional (non-weighted) segment can be added (if the assembly is less than 6-8 segments) or a weighted segment can be added. To add a non- weighted segment, please skip the rest of this section and refer back to section 1.6 through deployment. To add or replace a weighted segment, continue with this section.

15. The operator attaches the hook to the eye ring in the internal cord of the retracted segment.

16. The cable is raised slightly at first to ensure that the hook attachment piece is firmly attached to the cable end BTC. Once this bond is evident, the operator pulls back on the sliding pinplate.

17. Both cables are raised simultaneously until the two upper pins of the segment are above the pinblock. The pinplate can be released.

18. Both cables are raised simultaneously as the next BTC connection is above the pinblock. At this time, the sliding pinplate is again pulled back until the top pin of the next segment is above the pinblock.

19. The top cable is lowered until the top segment pin is securely placed into the torque slot of the pinblock.

20. The BTC coupling is disengaged.

21. The internal safety cord is disengaged.

22. The top segment is now released from the hoist hook and placed onto the glovebox rack.

23. The male coupling side of the next weighted segment to be used (as marked, intended, and recorded by the operators) is placed onto the hoist hook.

24. From this point on, the regular assembly procedure and pivot block attachment procedures can be used.

25. The operator now registers the new assembly information (changed length, load weight) with the software, and re-calibrates the cable lengths.

26. At this time changes in θ position can be implemented, and data set for the new radial position can be acquired.

1.13 Changing the Radioactive Source

This is the most painful of all procedures. Please follow the next 2 sections for Retrieval and Disassembly of Pole, then refer back to the beginning, Section1.3. It is recommended to call it a day first, and start fresh with a different source the following day.

1.14 Retrieval of Pole Assembly

1. Once calibration is complete, the system can be retracted weight end first for disassembly.

2. The cables can be moved back to the "start" position. This motion will be determined and run by the preset program, to avoid interference in the "excluded" region.

3. PMT high voltage will be turned off, and the cameras and LEDs turned on. The light cover can also be removed.

4. Once at the start position, the weighted end of the pole can be raised slightly until the lower cable is slack.

5. Both cables can be raised simultaneously until the pivot block is near the top of the spool stack. This may be determined by LED position, encoder readout, and possibly the cable fiducial.

6. The operator pulls back on the sliding plate on the pinblock as both cables are raised. Once the pivot block passes through, the slide plate can be released.

7. The operator detaches the pivot block .

8. Both cables are again raised simultaneously until the top pin of the weighted end segment is near the top of the spool stack.

9. The operator then pulls back on the sliding pin plate and raises both cables until the top pin of the weighted segment is above the pinblock.

10. The sliding pinplate is released and the cable lengths adjusted until the top pin of the weighted segment is securely placed into the torque slot of the pinblock.

11. The operator uses the torque wrench to disengage the cable end segment from the end of the weighted segment.

12. The upper cable is lifted slightly to allow the operator to disengage the internal safety cord.

13. At this time the hook attachment piece can be attached to the cable end BTC. This is done by first attaching the internal cords between the two pieces. Then the operator aligns the castellations and firmly hand tightens the coupling.

1.15 Disassembly

1. The top cable is lowered so that the hook is above the top of the retracted segment.

2. The operator attaches the hook to the eye ring in the internal cord of the retracted segment.

3. The cable is raised slightly at first to ensure that the hook attachment piece is firmly attached to the cable end BTC. Once this bond is evident, the operator pulls back on the sliding pinplate.

4. Both cables are raised simultaneously until the two upper pins of the segment are above the pinblock. The pinplate can be released.

5. Both cables are raised simultaneously as the next BTC connection is above the pinblock. At this time, the sliding pinplate is again pulled back until the top pin of the next segment is above the pinblock.

6. The top cable is lowered until the top segment pin is securely placed into the torque slot of the pinblock.

7. The BTC coupling is disengaged.

8. The internal safety cord is disengaged.

9. The top segment is now released from the hoist hook and placed onto the glovebox rack.

10. The above disassembly procedure is repeated until the entire pole assembly is retracted and stored safely in the glovebox.

11. Care should be taken upon retraction of segment 3, which requires sliding of the pinplate to allow the cable to pass through the pinblock.

12. All electrical connections need to be powered off and disconnected as they enter the glovebox.

13. After the second segment is retracted, the 16" gate valve can be closed. At this time detector high voltage can be turned on.

14. Once the source is retracted, the 6 gate valve can be closed.

15. At this time, purging of the spool stack, glovebox, and transfer box can begin. Sources can be removed from the glovebox at appropriate times during the purging procedure.